INDOOR AIR QUALITY REASSESSMENT

Allen Avenue School
290 Allen Avenue
North Attleborough, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program
August 2005

Background/Introduction

At the request of the North Attleborough School Department (NASD), the Massachusetts Department of Public Health's (MDPH) Center for Environmental Health (CEH) conducted an indoor air quality reassessment at the Allen Avenue School (AAS), 290 Allen Avenue, North Attleborough, Massachusetts. Over the past several years, the CEH has been conducting indoor air quality assessments in each of North Attleborough's public schools. The AAS was originally visited on October 21, 2004 by Cory Holmes, an Environmental Analyst in CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program; a March 2005 report detailed conditions found in the building at the time of the assessment (MDPH, 2005). On April 28, 2005, Mr. Holmes returned to the AAS to conduct a reassessment and observe progress/efforts undertaken by the NASD, AAS maintenance staff, administration and faculty to improve indoor air quality within the building.

Actions on MDPH Recommendations

As mentioned, MDPH staff had previously visited the building and issued a report with recommendations to improve indoor air quality (MDPH, 2005). A summary of actions taken on previous recommendations is included as Appendix A.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were conducted with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID).

Results

The school houses approximately 220 kindergarten through fourth grade students with a staff of approximately 30. Tests were taken under normal operating conditions and results appear in Table 1.

Discussion

Ventilation

Although a number of areas continued to have carbon dioxide levels above the MDPH guideline of 800 parts per million (ppm) (Table 1), mainly due to the absence of a mechanical exhaust system, levels in the majority of areas were significantly lower then the previous visit (MDPH, 2005), with the exception of the “portable” classrooms. As discussed in the March 2005 MDPH report, univents were not operating or were deactivated in a number of areas. During the reassessment, all univents were operating with fan controls set to the “medium” setting to draw in outside air. Occupants reported that operating the univent fans in the “high” setting created excessive noise and vibration.

The mechanical ventilation system in the gymnasium/cafeteria was not activated during the lunch hour. As discussed in the previous MDPH report, the gymnasium/cafeteria is equipped with two air-handling units located in lofts on each side of the stage. Fresh outside/heated air is distributed through supply vents on each side of the stage and return/exhaust air is drawn into a large vent below the stage. During the reassessment, MDPH staff pointed out the lack of operation to Principal Santos, who directed the school custodian to activate the system. The operation of this system is important for air exchange, especially since windows cannot be opened due to age and conditions.

Several areas (e.g., the computer room, main office) are not equipped with mechanical ventilation. Instead, fresh air is provided by open windows. However, window-mounted air conditioners (ACs) have been installed in these areas (Picture 1). To provide a mechanical means to introduce outside air, the ACs can be set to the "fan only" or "exhaust open" setting (Picture 2). When operating in either mode, air conditioning units can provide air circulation by delivering outside air without cooling (i.e., outside air temperature).

As discussed in the previous MDPH March 2005 report, exhaust ventilation in classrooms is provided through a combination of ducted, grated wall vents and coat closet vents powered by rooftop wind turbines. MDPH staff observed the function of the rooftop wind-turbines. Winds on day of the reassessment were reported to be from the west at 12 to 17 mph. All six wind turbines appeared to be rotating; although at different speeds (some appeared to be rotating more freely than others). However, even with the rotation of the wind turbines, little draw of air was detected from classroom exhaust vents.

As previously discussed, to maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools because a majority of occupants is young and considered a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information on carbon dioxide see Appendix B.

Temperature readings (ranged from 70^{o} F to 73 ^{o} F) were within the MDPH recommended comfort guidelines in all areas evaluated. The MDPH recommends that indoor air temperatures be maintained in a range of 70 ^{o} F to 78 ^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measurements ranged from 41 to 52 percent, which were within the MDPH recommended comfort range. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity would be expected to drop below comfort levels during the heating season. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Other IAQ Evaluations

Indoor air quality can be adversely impacted by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion products include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, MDPH staff obtained measurements for carbon monoxide and PM2.5.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide pollution and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient-Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from six criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the US EPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000).

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. *Carbon monoxide should not be present in a typical, indoor environment.* If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Outdoor carbon monoxide concentrations were non-detect or ND (Table 1). Carbon monoxide levels measured in the school were also ND (Table 1).

The US EPA has also established NAAQS limits for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits for particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 micrograms per cubic meter (μg/m^3) in a 24-hour average. This standard was adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM2.5 standard requires outdoor air particulate levels be maintained below 65 μg/m^3 over a 2 4-hour average. Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, MDPH uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 27 μg/m^3 (Table 1). PM2.5 levels measured indoors ranged from 9 to 20 μg/m^3. PM2.5 measurements were below background levels as well as the NAAQS of 65 μg/m^3. Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulate during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be impacted by the presence of materials containing volatile organic compounds (VOCs). VOCs are substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. Outdoor air samples were taken for comparison. Outdoor TVOC concentrations were ND (Table 1). Indoor TVOC measurements throughout the building were also ND (Table 1).

Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use of TVOC containing products. While no measurable TVOC levels were detected in the indoor environment, VOC-containing materials were noted. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat. -

Conclusions/Recommendations

NASD officials, working in conjunction with private contractors, AAS administration, faculty members and school maintenance staff, have improved indoor environmental conditions in the building by implementing the majority of MDPH's previous recommendations. As indicated in Appendix A, several of these recommendations need further action. In view of the findings at the time of this visit, the following additional recommendations are made to further improve indoor air quality:

1. Contact an HVAC engineering firm to determine the ability of portable classroom AHUs to introduce outside air. To improve air exchange in these classrooms an increase in the percentage of fresh air supply is recommended.

2. Continue to implement previous MDPH recommendations (MDPH, 2005). Particular consideration should be made regarding the retro-fitting/replacement of wind-driven turbines on the roof with modern mechanical exhaust motors.
3. Open windows to supplement the introduction of outside air from univents and improve air exchange/comfort in classrooms, particularly in the portable classrooms. Care should be taken to ensure windows are properly closed at night and weekends during the heating season to avoid the freezing of pipes and potential flooding.
4. Operate air conditioners in the "fan only" or "exhaust open" setting to introduce outside air.
5. Operate all ventilation systems that are operable throughout the building (e.g., gym/cafeteria, classrooms) continuously during periods of school occupancy independent of thermostat control.
6. Operate univent on "high" if more outside air is warranted and/or desired. As discussed, occupants reported excessive noise and vibration when operating the univent fans on the "high" setting.
7. Continue with the removal of tennis balls on chair and table legs throughout the school.

References

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SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0.

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Picture 1

Window-Mounted Air Conditioner, Note Keypad Control in Corner has "Fan Only" Function

Picture 2

Close-Up of Window-Mounted Air Conditioner Control Knobs
Note the Knob on the Left has a "Fan Only" Function

Allen Ave Elementary School

290 Allen Avenue, North Attleborough, MA 02760

Table 1

Indoor Air Results

April 28, 2005

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
background		58	45	404	ND	ND	27				mostly cloudy, NW winds 10-15 mph.
cafeteria/gymnasium	100	72	44	954	ND	ND	20	N # open: 0 # total: 0	Y wall (off)	Y wall (off)	Hallway DO, windows inoperable, vent system off-reactivated by custodian per order of principal.
school psychologist	0	71	45	1000	ND	ND	9	N # open: 0 # total: 0	N	N	
reading	1	72	44	954	ND	ND	16	Y # open: 0 # total: 0	N	N	Hallway DO,
computer lab	2	73	52	1073	ND	ND	14	Y # open: 0 # total: 0	N	N	Hallway DO, window-mounted AC

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile

NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings

sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WD = water damage
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

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April 28, 2005

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
library	25	72	43	1018	ND	ND	19	Y # open: 0 # total: 0			Inter-room DO.
1	22	73	47	1076	ND	ND	17	Y # open: 1 # total: 0	Y univent	Y wall	Hallway DO, DEM, TB.
2	25	71	41	866	ND	ND	14	Y # open: 0 # total: 0	Y univent	Y	Hallway DO, DEM, PF.
3	25	71	44	794	ND	ND	14	Y # open: 0 # total: 0	Y univent	Y wall (weak)	Hallway DO, DEM.
4	24	72	45	1135	ND	ND	16	Y # open: 0 # total: 0	Y univent	Y (weak)	Hallway DO, DEM, TB.

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Allen Ave Elementary School | **Indoor Air Results**

290 Allen Avenue, North Attleborough, MA 02760 | **April 28, 2005**

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Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
5	23	70	43	733	ND	ND	14	Y # open: 0 # total: 0	Y univent	Y (weak)	DEM.
6	24	71	43	807	ND	ND	17	Y # open: 0 # total: 0	Y univent	Y (weak)	DEM, TB.
7 portable	21	73	48	1901	ND	ND	13	Y # open: 0 # total: 0	Y ceiling	Y ceiling	DEM, thermostat-fan "on".
8 portable	22	73	47	1689	ND	ND	12	Y # open: 0 # total: 0			Hallway DO, DEM, thermostat-fan "on".
K	1	72	48	777	ND	ND	20	Y # open: 0 # total: 0	Y univent	Y (weak)	Hallway DO, DEM, morning kindergarten class gone 30 min.

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April 28, 2005

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									Supply	Exhaust	
nurse	2	71	45	1057	ND	ND	17	Y # open: 0 # total: 0	N	N	Hallway DO,
resource room	0	73	50	1100	ND	ND	14	N # open: 0 # total: 0	N	N	AP, DEM.
main office	3	73	44	1112	ND	ND	16	Y # open: 0 # total: 0	N	N	lunch crowd in hallway.
Principal	2	73	44	1114	ND	ND	17	Y # open: 0 # total: 0	N	N	Hallway DO, window-mounted AC,
teacher's lounge	2	72	43	776	ND	ND	13	Y # open: 1 # total: 0	N	N	Hallway DO, window-mounted AC, DEM.

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Appendix A

Actions on MDPH Recommendations, Allen Avenue School, North Attleborough, MA

The following is a status report of action(s) taken on MDPH recommendations (**in bold**) based on reports from school officials, maintenance staff, documents, photographs and MDPH staff observations.

- **Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers throughout the AAS.**

  Action: An HVAC engineering firm was consulted to calibrate fresh air controls and dampers.
- **Operate all ventilation systems that are operable throughout the building (e.g., gym, auditorium, classrooms) continuously during periods of school occupancy and independent of thermostat control. To increase airflow in classrooms, set univent controls to "high".**

  Action: All ventilation systems were operating during the assessment, with the exception of the cafeteria. Controls for unit ventilators in classrooms have been set to "med" verses "high" to prevent excessive noise from airflow.
- **Set the thermostats for modular classrooms to the fan "on" position to operate the ventilation system continuously during the school day.**

  Action: Fans are set in the "on" position.

Appendix A

- **Remove all blockages from univents and exhaust vents to ensure adequate airflow.**

  Action: Blockages were removed and staff were instructed not to prevent airflow.

- **Replace water damaged wooden splashboard in classroom 1. Examine behind and around this areas for microbial growth. Disinfect areas of water leaks with an appropriate antimicrobial.**

  Action: Water damaged splashboard was replaced in classroom 1, as well as in a number of other classrooms.

- **Ensure roof leaks are repaired and repair/replace any remaining water-stained ceiling tiles.**

  Action: Roof leaks were repaired by a roofing contractor.

- **Ensure plants have drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary.**

  Action: Plants were equipped with drip pans.

- **Change filters for univents and window-mounted air conditioners as per the manufacturer's instructions or more frequently if needed. Vacuum interior of units prior to activation to prevent the aerosolization of dirt, dust and particulates.**

  Action: Filters are routinely changed and were clean during the reassessment.

- **Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.**

  Action: School staff have reduced clutter in classrooms to improve cleaning.

Appendix A

- **Consider discontinuing the use of tennis balls on chairs to prevent latex dust generation. Continue with plans to purchase "glides".**

  Action: Tennis balls in most rooms have been removed; however a few rooms still had tennis balls on chair legs.